# APPENDIX 7. VERIFICATION AND SYSTEMS INTEGRATION TEST REQUIREMENTS

## 1 SCOPE

The scope of this appendix defines requirements for the following:

- Testing of DV and the Adapter
- Interfaces and interoperability with the Booster, CAC, Ground, and Flight Operations.
- Ground Test Equipment (GTE), Ground Support Equipment (GSE), and Simulations/Models.

## 2 DV/ADAPTER INTEGRATION AND VERIFICATION TEST

### *2.1 DV*

The Contractor shall complete DV integration, testing, verification testing, and pre-ship functional testing prior to DV delivery to the Government RTO. The Contractor shall perform post-ship functional testing once the DV arrives at the Government RTO.

The Contractor shall support DV validation testing and system integration and test support activities through the completion of flight test.

### *2.2 Adapter*

The Contractor shall complete Adapter integration, testing, verification testing, and pre-ship functional testing prior to Adapter delivery to the Government RTO.

The Contractor shall perform post-ship functional testing once the Adapter arrives at the Government RTO.

The Contractor shall support Adapter validation testing and system integration and test support activities through the completion of flight test.

### *2.3 DV and Adapter*

The Contractor shall complete DV and Adapter integration, testing, verification testing, and functional testing prior to delivery to the Government

## 3 GROUND SUPPORT EQUIPMENT

The Contractor shall design, develop, test, operate, and maintain X-43C-unique GSE for the development, integration, integration test, verification test, functional testing (pre &

post shipment), preflight checkouts, operations, and maintenance of the DV and Adapter.

## *3.1 Hardware-in-the-Loop (HIL) Integration Test Stand (ITS)*

The Contractor shall be responsible for the design, development, operation, and maintenance of HIL ITS. This includes all hardware (non-flight qualified hardware is acceptable), Flight Software, Support SW, DV Simulation, and Test Stand Simulation Software.

The HIL ITS shall be used for the development, integration testing (HW/SW), and verification testing (HW/SW) of the VMS, the DV, and DV/Adapter combination.

## *3.2 Flight Clearance Engine*

The Contractor shall provide all GSE necessary to operate the FCE during 8-Ft. HTT testing.

The Contractor shall supply and maintain an ECU Software Load to support FCE testing in the LaRC 8-Ft. HTT.

## *3.3 GSE Interface(s)*

The GSE and GTE require connectivity to the DV, Adapter, and select internal subsystems for the purpose of, but not limited to:

- Functional Testing (Pre-Post Shipment)
- Validation Testing
- Software upload
- Day of Flight Servicing
- Pre-Flight Check-out

GSE shall interface with the DV and Adapter through GSE Interface(s).

The Contractor shall design and develop the DV and Adapter GSE Interface(s) to provide the following additional requirements:

- The GSE Interface shall be designed to eliminate (or minimize) disassembly in order to connect GSE.
- The GSE Interface shall be designed so that connecting GSE shall not invalidate completed HW/SW tests, such as DV Verification Test.
- The GSE Interface shall be designed so that connecting GSE shall not invalidate completed HW/SW QA activities.

- GSE Interface shall prevent incorrect connections to GSE.
- The GSE Interface shall provide the capability for GTE to intercept signals sent from the FMU and ECU, and to drive signals to the FMU and ECU.
- GSE Interface shall be functional when the DV is attached to Adapter/Booster/CAC.
- GSE Interface shall support flight-line operations that
    - Minimize personnel interaction and system closeout.
    - Accommodate environmental exposure.

## *3.4 DV Mission Simulation*

The Contractor shall supply and maintain an all-software DV mission simulation (DV SIM). The simulation shall be capable of real-time operation and batch mode processing.

With each updated version of the DV SIM, the contractor shall provide end-to-end check cases (initial conditions and expected results).

## *3.5 Separation Simulation*

The Contractor shall supply and maintain a separation (DV from Adapter) simulation (Separation SIM). The simulation shall be capable of batch mode processing.

With each updated version of the Separation SIM, the contractor shall provide end-to-end check cases (initial conditions and expected results).

# 4 DV VALIDATION SUPPORT

Validation testing will be performed by the Government at the RTO using the Vehicle Systems Demonstrator (VSD). The VSD will be capable of Aircraft-in-the-Loop flight validation testing using a Government - developed software simulation. The VSD is comprised of the DV Emulator and Government-developed mission simulation and hardware interface unit. The Government will develop the VSD for the following two purposes:

- For the development and optimization of validation test procedures prior to DV delivery to the Government RTO.
- DV Validation Testing at the Government RTO.

## *4.1 Vehicle System Demonstrator Support*

To support development of the VSD, the Contractor shall develop the following:

### 4.1.1 DV Emulator

The Contractor shall supply a DV Emulator to the Government RTO. The DV Emulator shall duplicate the electrical, mechanical, software functional and timing interfaces of the DV. The DV Emulator may use non-flight qualified parts that are functionally identical to the DV flight hardware.

The DV Emulator shall characterize the DV system and subsystems.

The DV Emulator shall be updated throughout the course of DV development, ground testing, and flight testing until the subsystem response to known inputs can be predicted to within a mutually-agreed tolerance based on ground test and flight test results. The Contractor shall provide configuration control of the DV Emulator to reflect the evolving DV design.

The DV and contractor-supplied DV Emulator shall interface with the VSD through the GSE interface.

The DV Emulator shall allow for isolation and extraction of components from the DV Emulator for the purposes of developing, optimizing, and running validation test procedures or the evaluation of component operation.

The Contractor shall perform verification testing of the DV Emulator prior to delivery.

The Contractor shall provide on-site engineering and technician support for the DV Emulator at the Government RTO.

### 4.1.2 DV Emulator Core Components

As precursor to the DV Emulator delivery, the Contractor shall deliver a set of DV Emulator Core Components (non-flight qualified that pass the acceptance test criteria) for purposes of aiding development of and initiating integration with the VSD and associated simulation environment.

At a minimum, the Core Components shall include the following:

- Flight Management Unit including cables
- Engine Control Unit including cables
- Control surface actuators and controllers
- Instrumentation processing unit(s)
- GSE interface hardware
- Associated wiring harnesses (component-to-component and component-to-GSE interfaces)
- GPS Simulator

- Inertial Simulator

The Contractor shall provide on-site engineering and technician support for the DV Emulator Core Components at the Government RTO.

#### 4.1.3 Models, Simulations, & Data Products

To support Government simulation development for the VSD, the Contractor shall deliver identified software models.

These models shall characterize the DV system and subsystems, including non-linear elements, but not limited to, discretization, dead-band, friction, and noise.

The models and documentation shall be updated and refined throughout the course of DV development and flight testing until their subsystem response to known inputs can be predicted to within a mutually-agreed upon tolerance based on model and flight-test results.

The Contractor shall perform verification testing of the models prior to delivery.

#### 4.1.4 Models, Simulations & Data Products Accessibility

The Contractor shall archive all versions of the models on the SDDS.

#### 4.1.5 Model/Simulation Reconciliation

Model verification and simulation reconciliation shall consist of the following activities:

The Contractor shall develop end-to-end check cases (vehicle state, model I/O, vehicle inputs, expected outputs) to compare the Contractor simulation and the Government simulation.

The Contractor shall run the end-to-end check cases against both the Contractor and Government simulations.

The Contractor shall complete an analysis of the results to identify discrepancies, explain associated root causes, and provide recommendations to reduce the differences.

After simulation reconciliation, the Contractor shall provide check cases and a report of the results.

## *4.2 Validation Test Support*

The Contractor shall support the X-43C Validation Test Readiness Review(s).

The Contractor shall provide on-site engineering and technician support for DV validation testing performed at the RTO.

During DV Validation Testing the Contractor shall:

- Support the DV and Adapter preparation for Validation Testing,
- Expedite the communication of detected anomalies to the Contractor's facility for analysis and correction if required,
- Facilitate the communication and resolution of technical issues.
- Provide technical assistance to facilitate the successful completion of Validation Testing.

# 5 SYSTEM INTEGRATION AND TEST SUPPORT

The Contractor shall provide on-site DV and Adapter engineering and technician support for integration and testing performed at the Government RTO.

During DV, Adapter, and Booster integration and testing the Contractor shall:

- Support the DV and Adapter preparation for integration and testing activities.
- Expedite the communication of detected anomalies to the Contractor's facility for analysis and correction if required,
- Facilitate the communication and resolution of technical issues,
- Provide technical assistance to facilitate the successful completion of integration and testing activities,

During LV, CAC, and Flight Operations Facilities integration and testing the Contractor shall:

- Support LV, CAC, and Ground and Flight Operations preparation for integration and testing activities,
- Expedite the communication of detected anomalies to the Contractor's facility for analysis and correction if required,
- Facilitate the communication and resolution of technical issues,
- Provide technical assistance to facilitate the successful completion of integration and testing,
- Assist in Range Planning
- Assist in the development and review of Flight Test Cards
- Assist in the development and review of Emergency Procedures
- Assist in the development and review of Mission Control Center Displays.

- Participation in Mission Training.

# 6 FLIGHT TEST OPERATIONS SUPPORT

The Contractor shall provide on-site DV and Adapter engineering and technician support for Flight Test Operations.

During Flight Test Operations the Contractor shall:

- Support the DV and Adapter preparation for Flight Test Operations, including instrumentation and functional preflight checkouts
- Expedite the communication of detected anomalies to the Contractor's facility for analysis and correction, if required
- Facilitate the communication and resolution of technical issues
- Provide technical assistance to facilitate the successful completion of Flight Test Operations
- Support Mission Control Center
- Support flight briefings and debriefings